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(54) **SERVICE-BASED POLICY FOR CELLULAR COMMUNICATIONS**

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H04W 76/16 (2018.01)
H04W 76/10 (2018.01)

(52) **U.S. Cl.**
CPC ***H04W 76/10*** (2018.02)

(58) **Field of Classification Search**
CPC H04W 76/10; H04W 76/16; G06F 16/211; G06F 16/258
See application file for complete search history.

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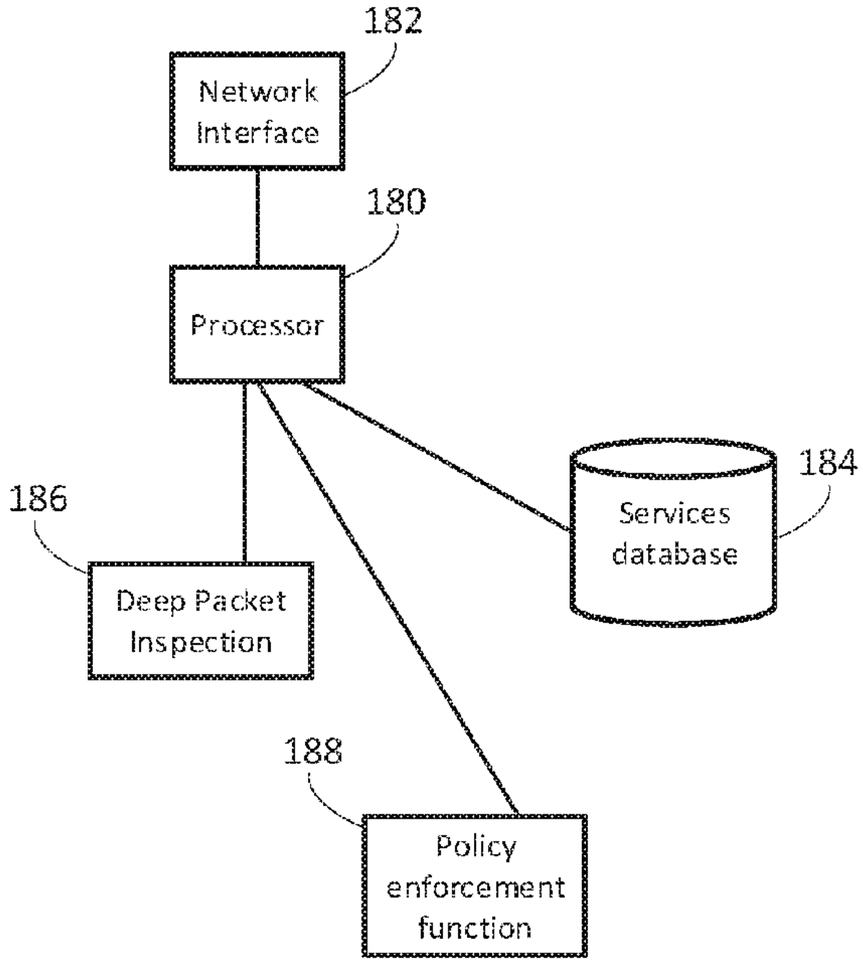
(57) **ABSTRACT**

A system uses deep packet inspection and a services policy database to select policy control functions based on services associated with a packet data session rather than an access point name or data network name. As a packet data session is initiated, a system management function (SMF) determines a service associated with the session and routes a policy request to one of several policy control functions (PCF or PCRF) depending on the service. Policies specific to the service may be chosen and enforced at the selected PCF/PCRF.

10 Claims, 5 Drawing Sheets



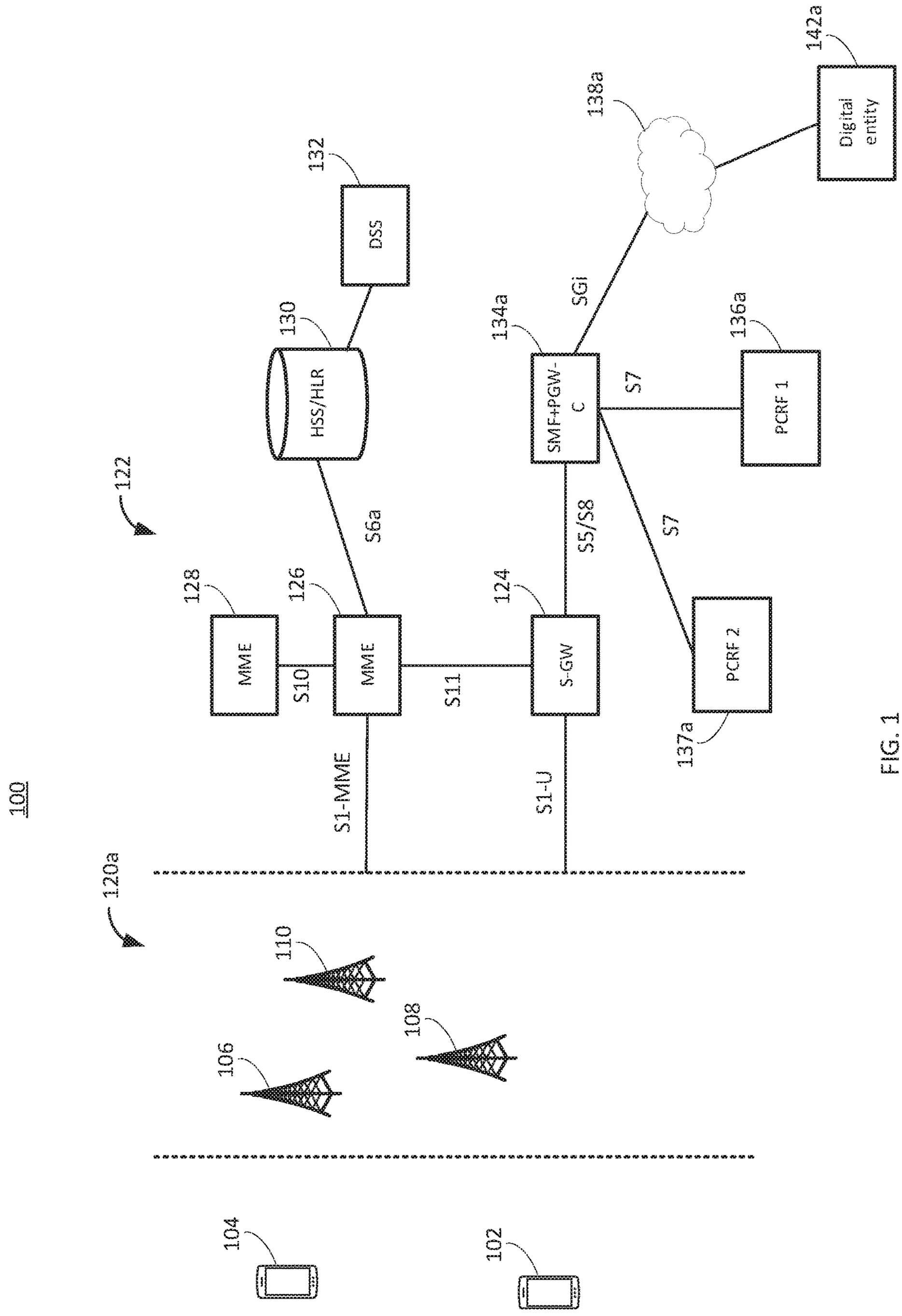

100
102
104
106
108
110
120a
122
124
126
128
130
132
134a
136a
137a
138a
142a
DSS
HSS/HLR
MME
MME
S-GW
SMF+PGW-C
PCRF 1
PCRF 2
Digital entity
S1-MME
S1-U
S10
S11
S5/S8
S6a
S7
S7
SGi

FIG. 1

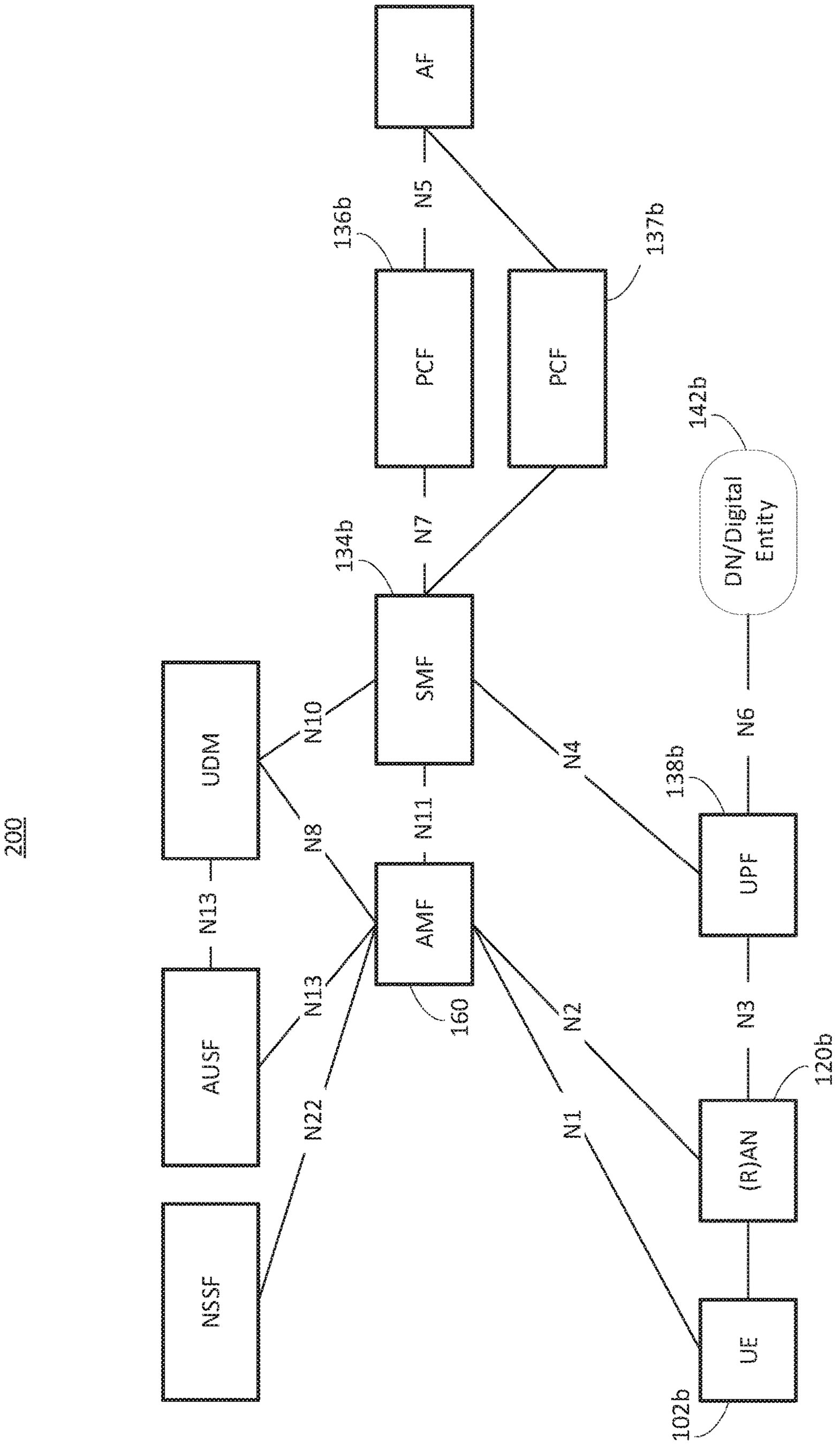

200
AF
N5
136b
137b
PCF
PCF
N7
134b
SMF
N10
N11
N4
UDM
N8
AMF
N13
N13
AUSF
N22
NSSF
160
142b
DN/Digital Entity
N6
138b
UPF
N3
N2
N1
120b
(R)AN
UE
102b

FIG. 2

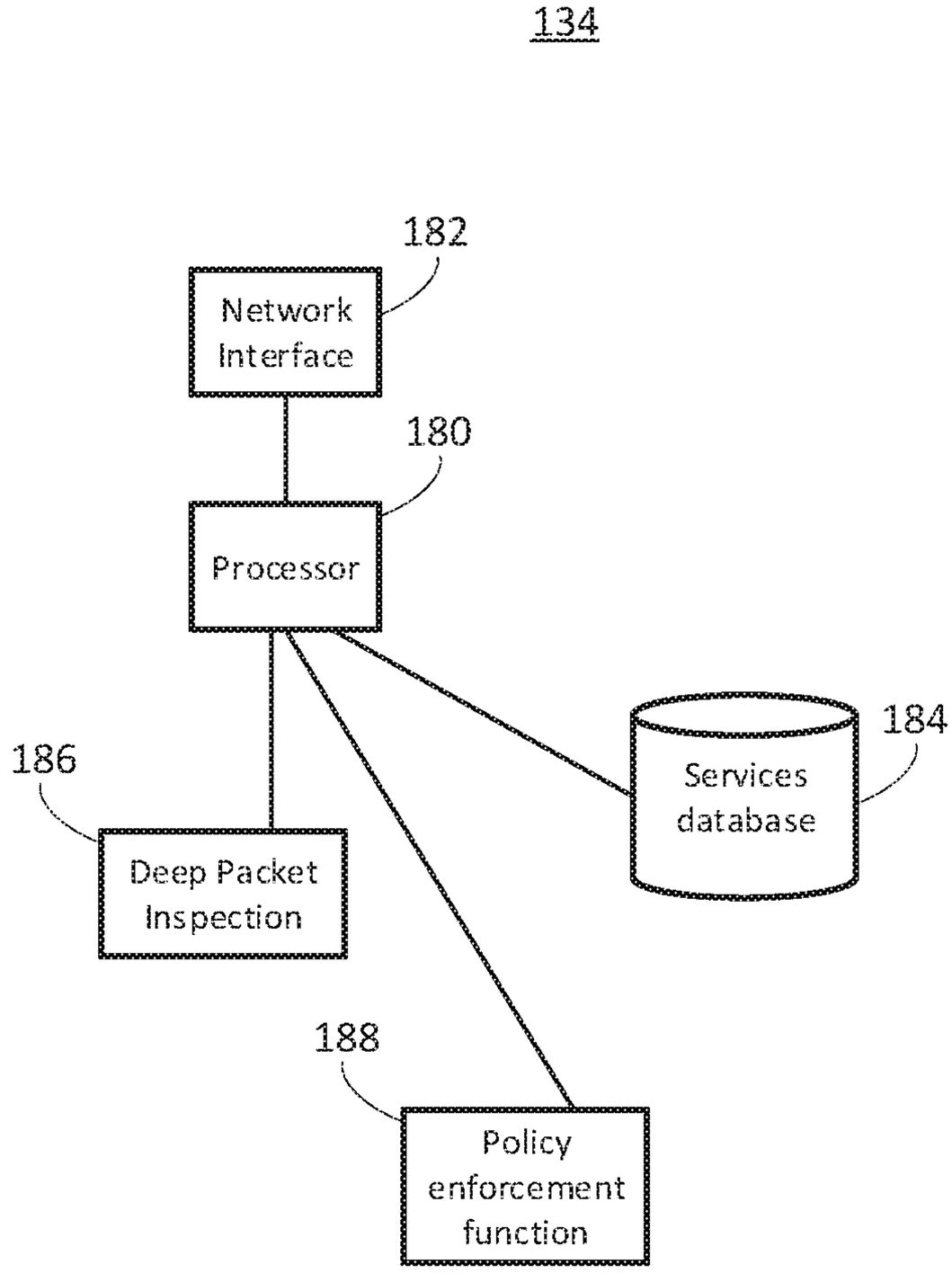

134
182
Network Interface
180
Processor
186
Deep Packet Inspection
184
Services database
188
Policy enforcement function

FIG. 3

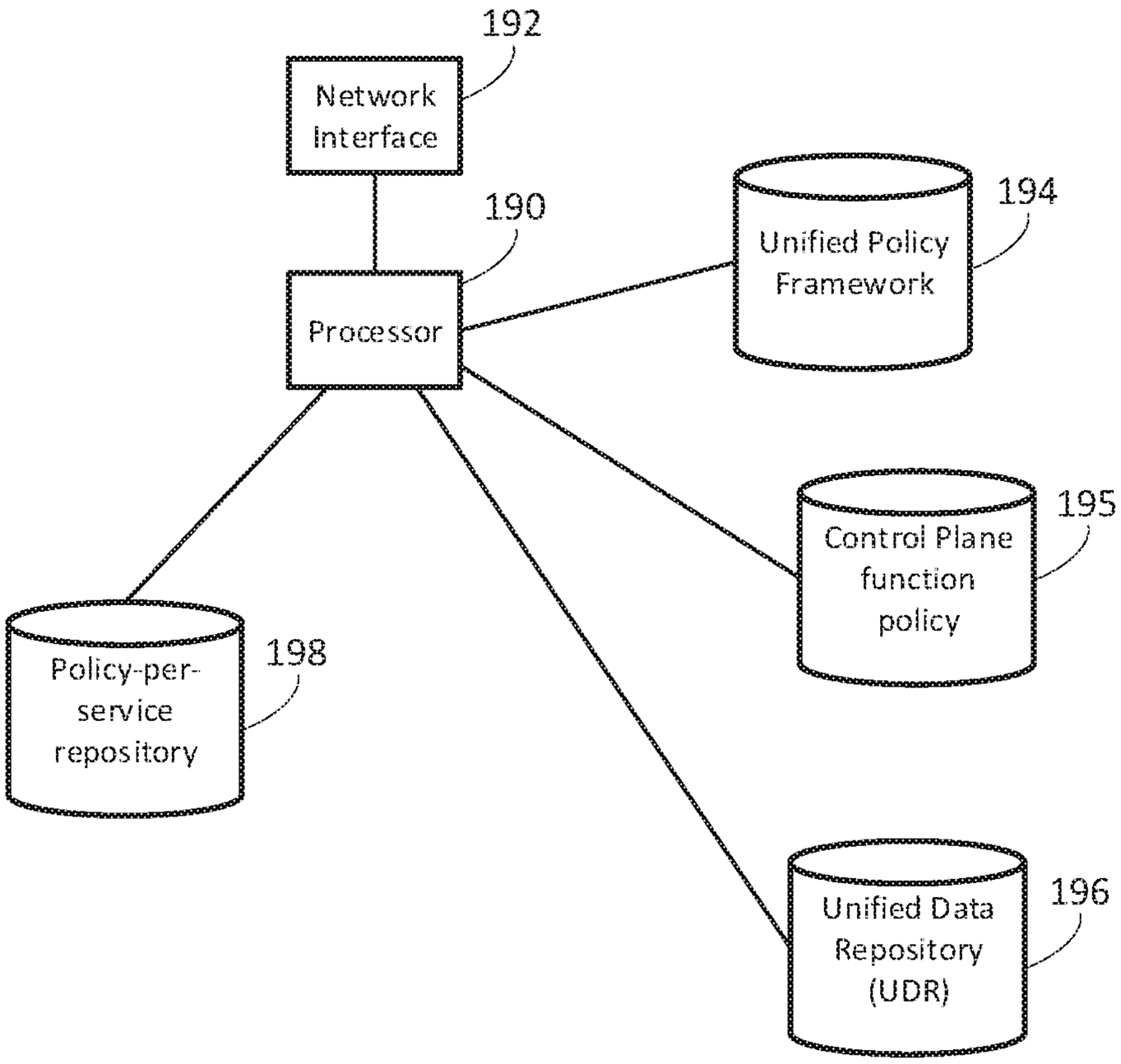

136
192
Network Interface
190
Processor
194
Unified Policy Framework
195
Control Plane function policy
198
Policy-per-service repository
196
Unified Data Repository (UDR)

FIG. 4

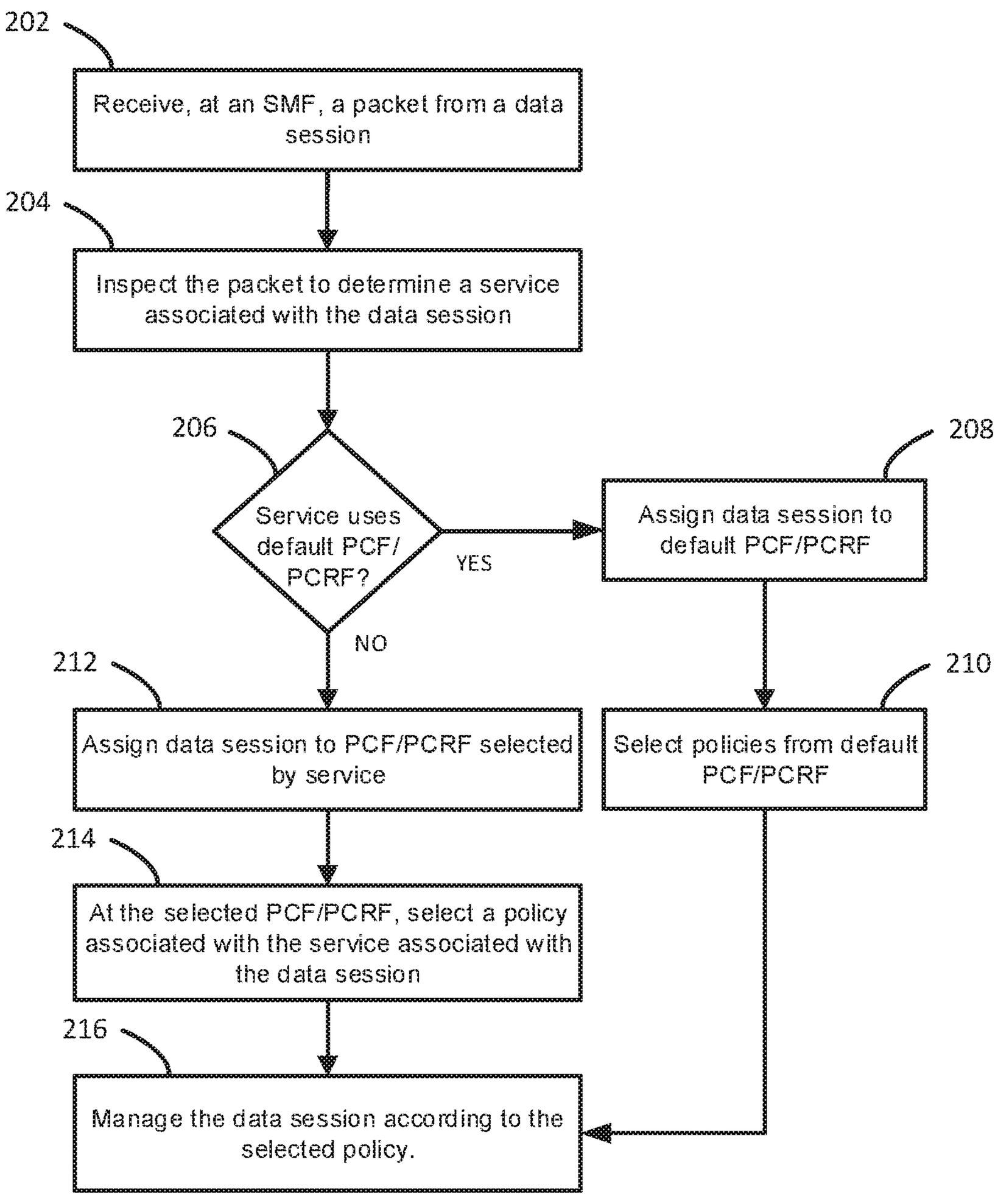

200
202
Receive, at an SMF, a packet from a data session
204
Inspect the packet to determine a service associated with the data session
206
Service uses default PCF/ PCRF?
YES
NO
208
Assign data session to default PCF/PCRF
210
Select policies from default PCF/PCRF
212
Assign data session to PCF/PCRF selected by service
214
At the selected PCF/PCRF, select a policy associated with the service associated with the data session
216
Manage the data session according to the selected policy.

FIG. 5

SERVICE-BASED POLICY FOR CELLULAR COMMUNICATIONS

BACKGROUND

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

3GPP architectures specify that a policy for a session is selected based on the connection point, that is, the Access Point Name (APN) for 4G or the Data Network Name (DNN) for 5G. These architectures specify that the same policy applies for all packet data sessions via that connection point.

SUMMARY

A service-based policy architecture allows multiple policies to be applied to different services accessing the same APN/DNN. A gateway may inspect packets for content indicating the service and direct the session to different policy charging and rule functions (PCRFs) so that each service may be handled separately.

BRIEF DESCRIPTION OF THE DRAWINGS

The figures depict a preferred embodiment for purposes of illustration only. One skilled in the art may readily recognize from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

FIG. **1** is an simplified and exemplary block diagram of a 4G cellular communication system in accordance with the current disclosure;

FIG. **2** is an simplified and exemplary block diagram of a 5G cellular communication system in accordance with the current disclosure;

FIG. **3** is a block diagram of an exemplary system management function in accordance with the current disclosure;

FIG. **4** is a block diagram of an exemplary policy control function in accordance with the current disclosure; and

FIG. **5** is a flowchart of a method implementing a service-based policy for cellular communications.

DETAILED DESCRIPTION

As a mobile device can (and usually does have) have several IP addresses (or IPv6 prefixes) at once, for example, one for Internet access and one for operator services such as voice over LTE (VoLTE), each is bound to a different virtual network interface on the device. In this case, several protocol data unit (PDU) sessions are established simultaneously. Each is identified with a (human readable) name which in 2G, 3G and 4G networks was referred to as the APN (Access Point Name). In the 5G core, it is referred to as the DNN (Data Network Name).

Each session is how controlled by a set of policies according to the APN/DNN. For example, the subscriber may be charged based on use of a high volume application or have volume limits applied during peak usage hours. However, only one set of policies may be applied to each session according to the policy and charging rules function (PCRF) associated with the APN/DNN.

A system in accordance with the current disclosure performs a deep packet inspection on protocol data units (PDUs) to determine a service with which the PDU is associated. The PCRF and therefore the policy for a particular packet session associated with those PDU's is then selected based on the service rather than the APN/DNN for that session.

Turning to FIG. **1**, a block diagram illustrates an exemplary embodiment of a system **100** in accordance with the current disclosure. The system **100** may include a plurality of subscriber devices **102**, **104** in communication with a radio access network (RAN) **120** including cell sites **106**, **108**, **110** and other infrastructure equipment not depicted in FIG. **1**.

Managing communication between subscriber devices and between a subscriber device and an external data entity (the outside world) **142**, is a core network **122**, called in a 4G LTE example, the evolved packet core (EPC). The core network **122** illustrated here is greatly simplified for the sake of clarity. A serving gateway **124** may act as a router between cell sites **106**, **108**, **110** and the rest of traffic-oriented components. Mobility management entities (MMEs) **126**, **128** manage signaling to the base stations including call set up and handoffs. A home subscriber server (HSS) **130** may be a central database that contains information about all the subscribers to the operator's communication system **100**. In older communication system configurations the role of the HSS was performed by a home location registry (HLR). The HSS **130** may provide other system components with subscriber operational information. The functions and data associated with a prior art HSS may be found in several standards documents such as 3GPP TS 22.041. A dynamic subscriber profile service (DSS) **132** manages subscriber profiles. In some embodiments, the DSS **132** may be embodied within the HSS **130**. In other embodiments, an equipment identity register (EIR) may be incorporated in the DSS **132** for device whitelisting and blacklisting among other functions. A session management function-packet data network gateway control (packet data gateway, or P-GW) **134***a* may handle communication between subscriber devices **102**, **104** and the outside world or endpoint, the digital entity **142***a*. The digital entity **142***a* may be coupled to the core network via access point **138***a*.

Policy servers **136***a* and **137***a*, known separately in the 4G example as a policy control and charging rules function (PCRF) are responsible for control decision-making and flow-based charging. In an embodiment, the policy server **136***a* may instruct the P-GW **132** to enforce the PCRF's decisions via a policy control enforcement function (not depicted in FIG. **1**) which may reside in the P-GW **132***a*. In a prior art embodiment, the selection of a policy server would be made by the P-GW **132** based on the APN being accessed, in this example, the APN **138***a*. As described herein, the P-GW **132***a* may select from multiple PCRFs **136***a*, **137***a* based on the service associated with a data communication, described in more detail below.

FIG. **2** illustrates a cellular communication network **200** supporting 5G communications. Reference numbers from FIG. **1** are reused for corresponding roles/functions in FIG. **2**. A subscriber device **102***b* may be connected to the network via a radio access network **120***b*. In this example, the subscriber device **102***b* may also be connected to an Access and Mobility Management Function (AMF) **160**. A session management function (SMF) **134***b*. The SMF **134***b* is responsible for checking whether requests from the sub-

scriber device **102***b* are compliant with the user's subscription including session types and quality of service (QoS) limits using policies stored in a first policy control function **136***b* and a second policy control function **137***b*. That is, the SMF **134***b* selects a PCF that is used for policy identification and enforcement. The user plane function (UPF) **138***b* provides the interface to the outside world, illustrated as digital entity **142***b*. As above, in the prior art implementation, the SMF **134***b* selects a PCF **136***b* or **137***b* based on the data network name (DNN) to which a particular data session is connected. In the network **200** in accordance with the current disclosure, the SMF **134***b* may select a PCF based on the service associated with the data session, not its DNN. The selection of more than one PCF **136***b* or **137***b* allows policy settings, such as service levels, to be tailored by application/service rather than by a data connection's access point.

Two elements of the networks **100** and **200** support the service-based selection of policy control functions. FIG. **3** illustrates an exemplary session management function **134**. The SMF **134** may include a network interface **180** coupled to a processor **182**. The processor **182** may be connected to a services database **186** that stores information about the various services supported by the networks **100** and **200**. These services may include, but are not limited to, voice over LTE (VOLTE), rich communication services (RCS), support for various Internet of Things (IoT) devices, or services that allow the use of one phone number across multiple devices such as T-Mobile's DIGITs service.

For example, a system in accordance with the current disclosure allows one PCRF/PCF to be selected for a Voice over LTE (VOLTE) service while a different PCRF/PCF to be selected for a Rich Communication Service (RCS) for communications from the same subscriber device **102**. In another embodiment, a subscriber device supporting separate 4G and 5G sessions using different IP Media Subsystems (IMS) may be directed to separate PCRFs **136***a*, **137***a*, **136***b*, **137***b*.

An exemplary session management function (SMF) **134***a*, **134***b* is illustrated in FIG. **3**. The SMF **134***a*, **134***b* may include a processor **180** coupled to a network interface **182** used to communicate with other components of the system **100**, **200**. A services database **184** may hold a list of services supported by the system **100**, **200**, such as VOLTE and video over LTE (VILTE). A deep packet inspection module **186** may inspect packets to determine not only their origin and destination but the type of service with which the packet's session is associated. The deep packet inspection module **186** may reference the services database **184** to match data found in packets to supported services. A policy enforcement function **188** of the SMF **134***a*, **134***b* may enforce policies selected via the PCRF **136***a*, **137***a*, **136***b*, **137***b* as well as its own policies related, for example, to QoS.

FIG. **4** illustrates an exemplary PCF/PCRF **136**. The PCF/PCRF **136** may include a processor **190** coupled to a network interface **192** used to communicate with other system elements. The PCF/PCRF **136** may also include a unified policy framework (UPF) **194**, and for 5G systems, a control plane function policy **195**. Another component of the PCF/PCRF **136** may be a unified data repository (UDR) **196** that may be used to store, among other things, packet flow descriptions for application detection and subscription data.

A policy-per-service repository **198** may store policies such as data limits, QoS settings, and pricing related to specific services. In accordance with the current disclosure, these policies may differ between PCRF's, such as PCRC **136***a* and **137***a* or PCF **136***b* and **137***b*. The ability to direct policy requests related to a data session's service is supported, in part, by the service-based policy repository **198**.

A method **200** of implementing a service-based policy for cellular communications is illustrated in the flowchart of FIG. **5**. At block **202**, a data packet may be received at an SMF/P-GW **134**, the data packet being associated with a data communication session, for example, a voice call or an internet query. In an embodiment, the packet may not include actual user data but may be associated with the setup of the data communication session between endpoints. The SMF/P-GW **134** may inspect not only the packet header but may inspect the contents of the packet (deep packet inspection) to determine a service associated with the data communication session. The service may be compared at block **206** to a list of services, for example, stored in a services database **184** to determine if a special PCF/PCRF should be invoked. If not, a default PCF/PCRF, for example, PCRF **136***a* or PCF **136***b* may be selected based on the data session's APN/DNN, as done in the prior art. The default PCF/PCRF **136***a*, **136***b*, at block **210**, may identify the appropriate policy or policies according to the service information passed from the SMF/P-GW **134**. Other system elements, including the SMF/P-GW **134** may manage the data session using the selected policies at block **216**. As discussed above, these policies may apply to allowable use, data limits, bandwidth restrictions, and more.

Returning to block **206**, when the service identified does not use the default setting, the 'no' branch may be taken to block **212** where a different PCF/PCRF, such as PCF **137***b*, may be selected and a message may be sent to the selected PCF/PCRF. At block **214**, a policy or policies appropriate to the identified service may be selected and used, at block **216** to manage the data session.

At least one technical effect is the ability to expand the capability of 4G and 5G systems to increase the system flexibility related to policies managing different types of data sessions according to the service associated with that data session.

The current system and method benefit both users and system providers by allowing more flexibility in managing data sessions including bandwidth, data limits, and tariffs associated with different data sessions between the same subscriber device via the same APN/DNN.

The figures depict preferred embodiments for purposes of illustration only. One skilled in the art will readily recognize from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

Upon reading this disclosure, those of skill in the art will appreciate still additional alternative structural and functional designs for the systems and methods described herein through the disclosed principles herein. Thus, while particular embodiments and applications have been illustrated and described, it is to be understood that the disclosed embodiments are not limited to the precise construction and components disclosed herein. Various modifications, changes and variations, which will be apparent to those skilled in the art, may be made in the arrangement, operation and details of the systems and methods disclosed herein without departing from the spirit and scope defined in any appended claims.

The invention claimed is:

1. A cellular communication system comprising:

a server, configured for executing computer-executable instructions, wherein the computer-executable instructions comprising:

a session management function-packet data network gateway-control (SMF+PGW-C) including a deep packet inspection module, the deep packet inspection module determining a service, an origin, and a destination associated with a data packet;

a network connection between the SMF+PGW-C and a network access point, the network access point coupled to an external digital entity; and

wherein the server is configured to execute the computer-executable instructions for a policy control function (PCF) coupled to the SMF+PGW-C;

wherein the deep packet inspection module determines the service comprises the deep packet inspection module is configured to inspect a request for one of a plurality of data packet sessions, wherein the data packet comprises user data and session data; and

wherein the PCF includes a policy database according to the network access point and the service associated with the data packet, wherein the PCF is configured to select a policy for the data packet according to the data packet based on the service associated with the data packet.

2. The cellular communication system of claim **1**, wherein the processor is configured to execute the SMF+PGW-C to select a PCF based on the service associated with the data packet.

3. The cellular communication system of claim **1**, wherein the SMF+PGW-C includes a service identifier in a policy request made to the PCF.

4. The cellular communication system of claim **3**, wherein the PCF is configured to examine the request to identify the service associated with the data packet.

5. The cellular communication system of claim **1**, wherein the service is a voice over LTE (VOLTE) service.

6. The cellular communication system of claim **1**, wherein the service is a video over LTE (VILTE) service.

7. The cellular communication system of claim **1**, wherein the service is an Internet of Things (IoT) service.

8. The cellular communication system of claim **1**, wherein the policy comprises a data rate for the data packet.

9. The cellular communication system of claim **1**, wherein the policy comprises a tariff for the data packet.

10. A tangible non-transitive computer-readable medium stored thereon computer-executable instructions for a cellular communication system, wherein the computer-executable instructions comprising:

a session management function-packet data network gateway-control (SMF+PGW-C) including a deep packet inspection module, the deep packet inspection module determining a service, an origin, and a destination associated with a data packet;

a network connection between the SMF+PGW-C and a network access point, the network access point coupled to an external digital entity; and

wherein the server is configured to execute the computer-executable instructions for a policy control function (PCF) coupled to the SMF+PGW-C;

wherein the deep packet inspection module determines the service comprises the deep packet inspection module is configured to inspect a request for one of a plurality of data packet sessions, wherein the data packet comprises user data and session data; and

wherein the PCF includes a policy database according to the network access point and the service associated with the data packet, wherein the PCF is configured to select a policy for the data packet according to the data packet based on the service associated with the data packet.

* * * * *